Baseline Behavior of Pilot Whales and their Responses to Playback of Anthropogenic and Natural Sounds

Peter Tyack
Woods Hole Oceanographic Institution
MS#50
266 Woods Hole Road
Woods Hole MA 02543
phone: (508) 289-2818 fax: (508) 457-2041 email: ptyack@whoi.edu

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LONG-TERM GOALS

This project investigates the social ecology and baseline behavior of pilot whales, and responses to controlled exposures of anthropogenic and natural sounds. The ultimate goal is to understand responses of different cetacean taxa to naval sonar, which should improve Navy environmental analyses.

OBJECTIVES

Our objectives here are to: i) identify a field site where we can resight known groups of pilot whales reliably across field seasons. ii) Selectively tag highly associated individuals so as to iii) investigate social dynamics and social cohesion mechanisms within pilot whale social groups and iv) conduct controlled exposure experiments of sonar and killer whale sounds to test whether and how pilot whales may use these mechanisms in social defense against threats.

APPROACH

This project supported a two-month field expedition to the Strait of Gibraltar, Spain, in collaboration with CIRCE (Conservación, Información y Estudio sobre Cetáceos). This field site is unique in that the year-round resident population of pilot whales (de Stephanis et al., 2008a) is relatively small, around 200 individuals (Verborgh et al., 2009), and with well-known social structure (de Stephanis et al., 2008c). We selectively tagged groups of pilot whales with acoustic and movement logging DTAGs (Johnson & Tyack, 2003), followed animals at the surface while conducting visual observations and quantified social group cohesion using a stereo camera system under development, and conducted playback experiments to a subset of the tagged animals when conditions were favourable.

WORK COMPLETED

Fieldwork was completed between July 2nd and August 31st, 2012. This expedition was highly successful, providing us with 33 DTAGs on pilot whales and a total of 184 hours of DTAG data (Table 1). We were able to meet our goal of choosing and selectively tagging highly associated individuals within the same social group, with 3 or more simultaneous tags were placed on whales in each of 5 highly cohesive groups of animals (Figure 1). While two groups were immigrants who visit the Strait

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nearly every summer, the remaining groups were year-round residents. All tagged individuals were fully identified, enabling us to target the same individuals and groups during future expeditions, retagging these animals and potentially exposing them to playbacks.

Table 1: Summary of tag deployments during summer 2012 expedition (Gibraltar, Spain)

Tarifa 2012 Cruise summary

Date	Dataset	Tag On time	Duration (hours)	Reason for Release
4th July	gm12_186a	13:08	0,2211	Rubbed off
9th July	gm12_191a	13:18	2,3961	Rubbed off
25th July	gm12_207a	15:11	13,6628	Programmed
25th July	gm12_207b	15:34	1,0489	Breach
25th July	gm12_207c	16:09	7,4288	Rubbed off
25th July	gm12_207d	16:48	10,0597	Programmed
25th July	gm12_207e	17:06	0,1446	Breach
25th July	gm12_207f	17:48	4,4479	Rubbed off
29th July	gm12_211a	10:52	1,5112	Sprint
29th July	gm12_211b	11:14	0,0153	Slid off
29th July	gm12_211c	14:07	1,1598	Rubbed off
29th July	gm12_211d	14:20	~8	Breach
3rd August	gm12_216a	08:49	4,2800	Rubbed off
3rd August	gm12_216b	11:04	0,1053	Breach
3rd August	gm12_216c	14:01	0,0089	Breach

Date	Dataset	Tag On time	Duration (hours)	Reason for Release
4th August	gm12_217a	08:15	15,5005	Programmed
4th August	gm12_217b	09:00	15,4059	Programmed
4th August	gm12_217c	09:13	4,8609	Breach
4th August	gm12_217d	09:44	1,6424	Rubbed off
4th August	gm12_217e	12:17	3,6367	Sprint
4th August	gm12_217f	17:12	7,2644	Programmed
11th August	gm12_224a	09:51	4,3616	Fast swim
11th August	gm12_224b	09:59	4,5701	Fast swim
11th August	gm12_224c	10:23	6,9581	Foraging sprint
11th August	gm12_224d	11:38	14,6764	Programmed
16th August	gm12_229a	08:52	11,3700	Programmed
16th August	gm12_229b	09:29	10,2565	Fast swim
16th August	gm12_229c	11:44	8,0058	Fast swim
28th August	gm12_241a	10:06	0,8796	Deep dive
29th August	gm12_242a	09:13	9,2332	Programmed
29th August	gm12_242b	09:16	8,2890	Fast swim
29th August	gm12_242c	09:56	3,0949	Foraging sprint
29th August	gm12_242d	12:18	1,8734	Foraging sprint

We succeeded in obtaining multiple datasets of simultaneously tagged group members. Figure 1 shows a time-depth plot of simultaneous tags from our last tag deployment day on the 29th of August. In this example, we tagged a trio of highly associated animals, while an individual within the same group, but in another subgroup, was tagged part of the time as a control. As with pilot whales in the Alboran Sea, foraging dives were often synchronized, but with several instances of one or two whales leaving the remaining animals at the surface while going on a foraging dive, so we are optimistic that upcoming analyses will help us to quantify differences in acoustic signals and calling behavior during varying degrees of social group separation.

During the field period, we managed to conduct playbacks of killer whale calls and pseudorandom noise to a group of 3 simultaneously tagged animals. While these data are still to be analysed, they will contribute towards our data collection on how pilot whales respond to anthropogenic and natural sounds.

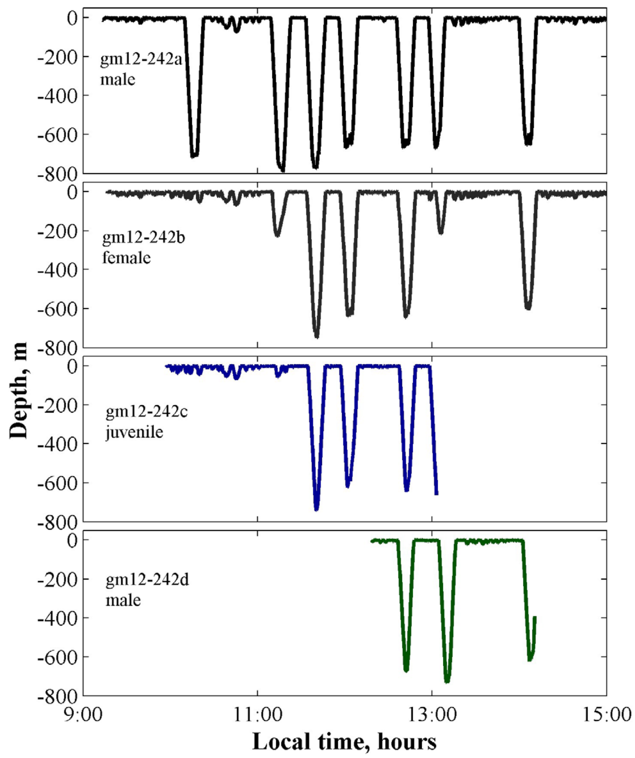

Figure 1: Example of simultaneous tagging of 4 long-finned pilot whales on the 29th of August, showing depth profiles as a function of time. Animals A to C were in a tight subgroup, whereas animal D was part of the same group, but a different subgroup less tightly associated with the trio.

RESULTS

During the summer 2012 expedition, we achieved a remarkably high resighting rate. At the conclusion of the fieldwork, we estimated around 80-90 different animals were sighted throughout the month, with most groups sighted on nearly every day spent at sea. All tagged animals were identified and linked to previous observations and information from social association studies (de Stephanis et al., 2008c) and studies of foraging ecology using stable isotopes (de Stephanis et al., 2008b). This remarkable extent of identification of animals and high resighting rate gave us a great flexibility in choosing the right animals at the right moment for tagging, and makes it very likely that we would be able to find and retag the same animals across field seasons.

While satellite tagging was successful, with two satellite tags deployed and providing us with long-term movement data of two groups during the tagging period, it seemed unnecessary for sighting animals. While the initial knowledge about where animals were located when we set out in the morning did help us find the animals somewhat faster, once animals were satellite tagged, they were highly evasive and we only managed to do a few DTAG attachments to these groups. We therefore expect to use few if any satellite tags in future projects.

This expedition allowed us to field test the second version of the stereo videocamera system under development for quantifying surface group movement and social cohesion of cetaceans (Figure 2). The system works well under relatively calm sea states. One important issue that we are still improving is how to accurately label the individual animals when they are too far away to be recognized on the pictures collected with the stereo camera system. With accurate identification, the position of animals can be roughly interpolated between surfacings, giving us a higher time resolution of the 2D location of animals, and more reliable estimates of speed-over-ground as well as orientation changes. We plan to include a time synchronized audio recorder for verbally labelling individual animals as they surface, and further development of analysis software is also in progress.

Figure 2: The current stereo geocoding system for 3D localization of whales and quantification of social group cohesion. Left: Photo of the stereo camera system used in August 2012 field cruise, sampling at 4 Hz. Center: Image of 3 pilot whales similar to what is captured by one of the two cameras. Images from both cameras are analysed to find a distance to different whales using the known aperture and calibration values, and then combined with the GPS position and pointing vector of the camera to calculate georeferenced positions. Right: Conceptual illustration of geocoded position estimates of the three animals shown on image in the center. An initial RMS measure of social group cohesion could be derived as the root-mean-squared distance from each whale (dorsal fin location shown in blue circles) to the mean group position (red circle), for a mean group spread of 4.05 m in this example, and with individual distances between animals noted on figure. Range resolution for the current system is better than ±1m at 50 meters distance.

Both CTD casts and playbacks proved more difficult in this new study area than in the Alboran Sea, primarily because of the strong currents but also in part due to the heavy shipping traffic, which requires the ability to maneuver out of the way of oncoming ships. Our new proposal includes an expendable CTD system that would provide us with sound velocity profiles irrespective of current and traffic, to improve accuracy of sound propagation modelling. This is especially important during playbacks. To improve on the success of playbacks, we decreased the duration of the playbacks to half the duration of the playbacks used in the Mediterranean, for a playback duration of 7.5 minutes.

While we did not collect biopsies of all animals tagged, biopsies are collected by CIRCE throughout the year on good weather days. With all tagged animals identified, biopsies can be collected at any time, and kinship analysis can be conducted once samples from all animals within a group has been collected.

While the large amounts of data have barely been analysed yet, one hypothesis that our collaborators had before the field expedition was that the pilot whales tended to forage during the rising tide. Figure 3 illustrates the 5 simultaneous tag datasets collected this summer, with deep foraging dives highlighted and with the time of rising tide marked as shaded areas. Statistical analyses, taking into account the sampling effort and autocorrelation within groups, still need to be performed, but our data seems highly supportive of this tidal foraging hypothesis.

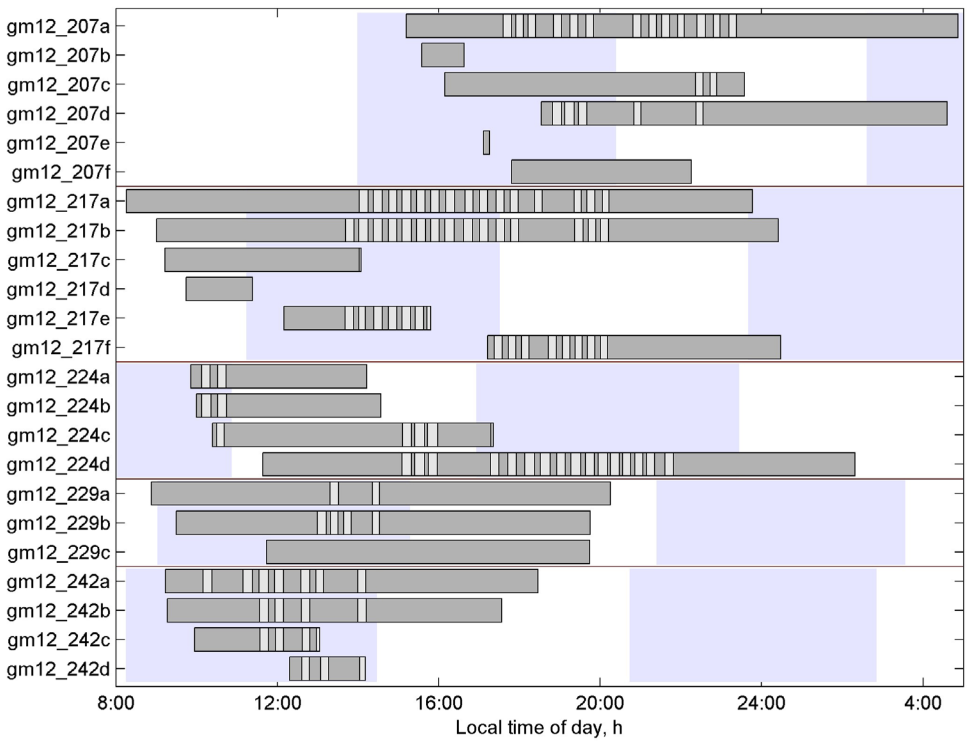

Figure 3: Graphical representation of the 5 simultaneous tag datasets collected in 2012, showing the duration where animals have been tagged as bars plotted against local time for each individual dataset (dataset ID along y-axis). Deep foraging dives have been indicated for each animal in a lighter grey shade, and daily rising tide is marked as shaded areas, with the start of each shaded area representing low tide, and the end of the shaded area representing high tide. Most foraging dives seem to occur during rising tide, supporting a tidal foraging hypothesis.

IMPACT/APPLICATIONS

An important research topic for the ONR Marine Mammals and Biology program is to study the responses of beaked whales and other whales to naval and anthropogenic sounds. This project is important for this topic on several levels: First, an increased understanding of the behavior and acoustic signalling during different degrees of social group separation provides an important set of contextual variables for interpreting and designing controlled exposure experiments to pilot whales. For these and other gregarious cetaceans, the group composition, spatial distribution and foraging activity presumably modulates the likelihood of response of individuals exposed to playbacks. Second, an important response variable for social delphinids exposed to disturbance is acoustic activity (DeRuiter et al., 2012) and data on individual and group social communication during different

behavioral states may help us better interpret the importance of changes in social signalling. Third, an important variable for responses is changes in orientation and movement (Pirotta et al., 2012; Tyack et al., 2011). The stereo camera system under development as part of this project is capable of measuring orientation and speed of animals, as well as quantifying changes in group cohesion that might be part of a possible defensive response to a disturbance.

RELATED PROJECTS

The 3S project and BRS AUTEC projects conducted controlled exposure experiments to pilot whales. The 3S project played back sounds of familiar fish-eating killer whales to pilot whales; this project uses sounds of unfamilar mammal-eating killer whales. We have provided data on our playbacks to 3S, filling a data gap from 3S. One of the biggest problems in analysing responses to playback involves high levels of variability in baseline behavior. This project seeks to understand the underlying factors and context that cause this variability. The MOCHA project (http://www.creem.st-and.ac.uk/mocha/) will use data from all of these projects as they develop new statistical methods to analyse these kinds of data within and across studies.

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